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RESEARCH MEMORANDUM

FLIGHT-DETERMINED PRESSURE DISTRIBUTIONS OVER A
SECTION OF THE 35° SWEPT WING OF THE DOUGLAS D-558-II
RESEARCH AIRPLANE AT MACH NUMBERS UP TO 2

By Gareth H. Jordan and Earl R. Keener

High-Speed Flight Station
Edwards, Calif.

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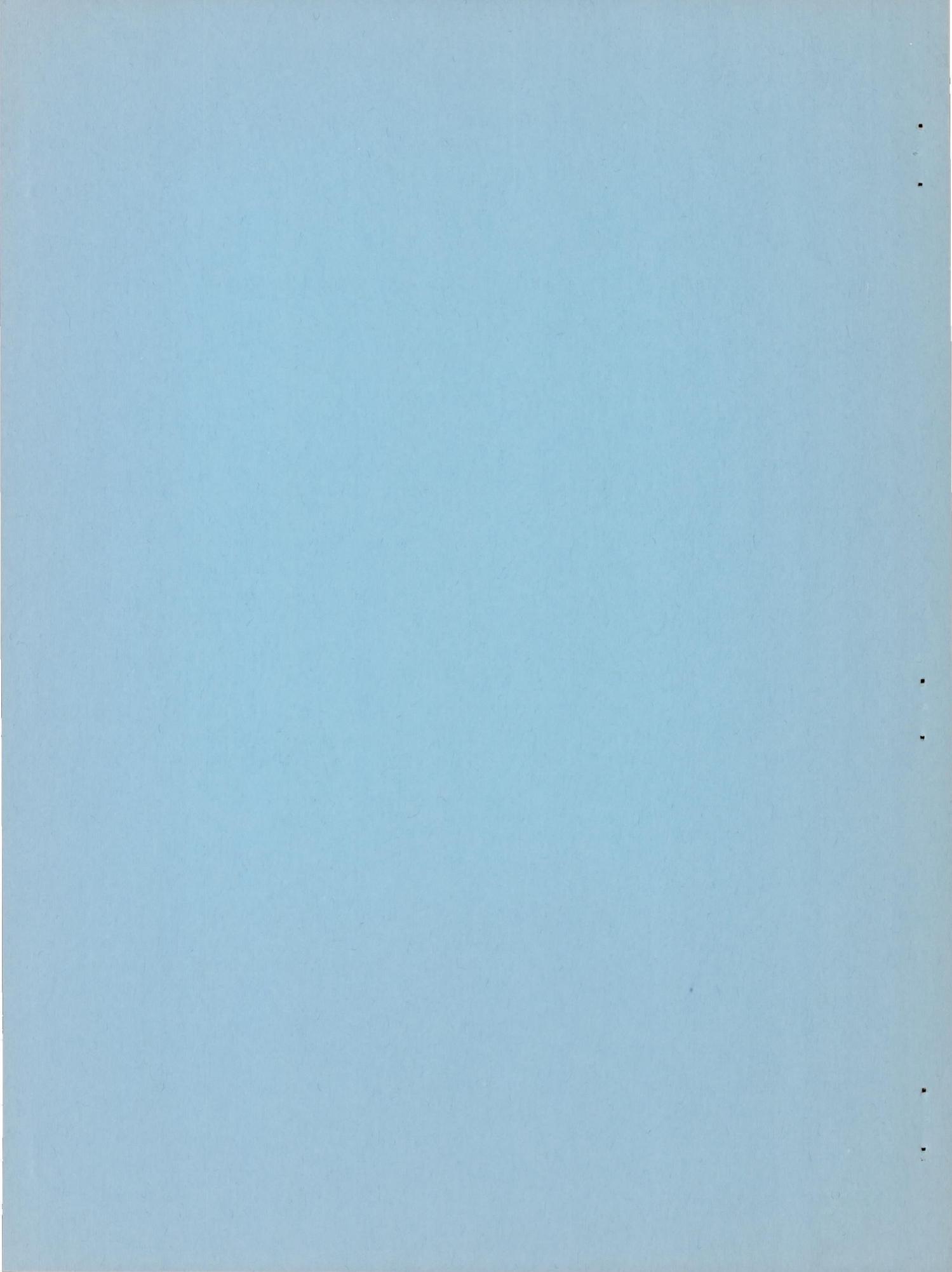
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RESEARCH MEMORANDUM

FLIGHT-DETERMINED PRESSURE DISTRIBUTIONS OVER A
SECTION OF THE 35° SWEPT WING OF THE DOUGLAS D-558-II
RESEARCH AIRPLANE AT MACH NUMBERS UP TO 2.0

By Gareth H. Jordan and Earl R. Keener

SUMMARY

Measurements of pressure distributions have been made over a wing midsemispan station on the 35° sweptback wing of the Douglas D-558-II research airplane at Mach numbers from 1.17 to 2.0.

The results of the investigation indicate that, as the angle of attack increased at the higher Mach numbers, the pressure coefficient for a vacuum limited the extent to which the upper-surface pressures could expand. Consequently most of the increase in section normal-force coefficient at high angles of attack can be attributed to the increase in pressure over the lower surface.

At high subsonic speeds the center of pressure rapidly moved rearward with increasing Mach number. At supersonic Mach numbers the center of pressure moved rearward both with increasing Mach number and with increasing angle of attack.

INTRODUCTION

Flight tests of the 35° sweptback wing of the Douglas D-558-II research airplane are being conducted by the NACA High-Speed Flight Station at Edwards, Calif. A pressure survey has previously been made of the wing surface to determine the chordwise and spanwise load distribution at subsonic and transonic Mach numbers. Some of these data have been reported in reference 1. Because of the interest in the wing section characteristics of subsonic-type airfoils at supersonic speeds, sufficient instrumentation was included in the airplane during recent exploratory flights at supersonic speeds to determine the chordwise pressure distribution of a midsemispan wing station perpendicular to the

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30-percent-common-chord line. The data presented herein show the effect of Mach number and angle of attack in the Mach number range of 1.17 to 2.00.

SYMBOLS

$b/2$ wing semispan, 12.5 ft

C_{N_A} airplane normal-force coefficient, nW/qS

c local wing chord of midsemispan station perpendicular to 30-percent-common-chord line, 5.88 ft

$c_{m_c}/4$ section pitching-moment coefficient about 0.25c,

$$\int_0^1 \frac{p_L - p_U}{q} (0.25 - x/c) \cdot d\frac{x}{c}$$

c_n section normal-force coefficient, $\int_0^1 \frac{p_L - p_U}{q} d\frac{x}{c}$

c_{n_U} contribution of upper surface to section normal-force

$$\text{coefficient, } \int_0^1 \frac{p_O - p_U}{q} d\frac{x}{c}$$

c_{n_L} contribution of lower surface to section normal-force

$$\text{coefficient, } \int_0^1 \frac{p_L - p_O}{q} d\frac{x}{c}$$

g acceleration due to gravity, ft/sec^2

M free-stream Mach number

n normal load factor, g units

P pressure coefficient, $\frac{p - p_O}{q}$

P_{cr}	critical pressure coefficient (pressure coefficient at sonic velocity), $\frac{2}{\gamma M^2} \left[\left(\frac{2}{\gamma + 1} + \frac{\gamma - 1}{\gamma + 1} M^2 \right)^{\frac{\gamma}{\gamma - 1}} - 1 \right]$
p	local static pressure, lb/sq ft
p_0	free-stream static pressure, lb/sq ft
q	free-stream dynamic pressure, lb/sq ft
S	total wing area, including area projected through fuselage, 175 sq ft
W	airplane weight, lb
x	chordwise distance rearward of leading edge of local chord, ft
x_{cp}	chordwise center of pressure, $\left(0.25 - \frac{c_m c / 4}{c_n} \right) 100$, percent chord
α	airplane angle of attack, deg
γ	ratio of specific heats

Subscripts:

L	lower surface
U	upper surface

DESCRIPTION OF AIRPLANE AND ORIFICE STATION

The Douglas D-558-II research airplane used in these tests is shown in figure 1. A three-view drawing of the airplane showing the general overall dimensions is shown in figure 2. Physical characteristics of the airplane are given in table I.

The airplane was designed for Mach numbers above 1.0, and has a wing whose 30-percent-common-chord line is swept back 35° . The wing taper ratio and aspect ratio are 0.565 and 3.57, respectively.

The orifice station for which data are presented in this paper is a midsemispan station, normal to the 30-percent-common-chord line, as shown in figure 3. This midsemispan station intersects the 30-percent-common-chord line at $0.574b/2$ and extends over the leading-edge slat and trailing-edge flap. The root and tip wing sections, normal to the 30-percent-common-chord line, are NACA 63-010 and 63₁-012 airfoils, respectively. The wing section thickness is 10.86 percent of the chord at the orifice station, the ordinates of which are presented in table II. For these tests the leading-edge slat was locked in the closed position and the trailing-edge flap was undeflected.

INSTRUMENTATION

Standard NACA instruments pertaining to the pressure-distribution measurements were installed in the airplane to record indicated free-stream static and dynamic pressures, normal acceleration at airplane center of gravity, airplane angle of attack, and angle of sideslip. All instruments were synchronized by a common timer.

An NACA high-speed pitot-static tube was mounted on a boom which projected from the nose of the airplane. The angle-of-attack and angle-of-sideslip vanes were attached to the nose boom. The position error introduced by the pressure field in the vicinity of the tube was calibrated by comparing the static pressure measured from the airspeed head and the altitude of the airplane measured by radar with the pressure and altitude determined from a radiosonde balloon released at the time of flight.

Flush-type orifices installed in the wing skin were connected by 1/8-inch-inside-diameter tubing to NACA 24-cell recording manometers located in the instrument compartment. The length of tubing varied from 15 to 20 feet. One side of each manometer cell was connected to the orifice and the other side was vented to the instrument compartment. The instrument compartment pressure was recorded separately to establish a reference pressure for the manometers.

TESTS AND METHODS

Wing section pressure-distribution data were obtained during two dives to $M \approx 2.0$ at altitudes from 70,000 to 55,000 feet and from wind-up turns at Mach numbers between 1.17 and 1.85 at altitudes from 45,000 to 65,000 feet.

Mach number and free-stream static pressure were obtained from the measured free-stream static and impact pressures by using the airspeed calibration mentioned previously. The measured wing surface pressures were reduced to pressure coefficients. Chordwise distributions of these pressure coefficients were plotted for the test section and mechanically integrated to obtain normal-force coefficient and pitching-moment coefficient.

ACCURACY

The accuracy of the test results is estimated to be within the following limits:

M	M = 1.2, ± 0.01
P	M = 2.0, ± 0.03
c_n	± 0.03
$c_{m_c}/4$	± 0.04
c_{N_A}	± 0.01
α , deg	± 0.02
	± 1.0

RESULTS AND DISCUSSION

Pressure Distributions

The chordwise pressure coefficients obtained at supersonic Mach numbers over the wing midsemispan station are given in tabular form in tables III to IX. From these data representative pressure distributions were selected that illustrate the changes that occurred with Mach number and angle of attack. Figures 4 and 5 show the effect of Mach number at $c_n \approx 0.25$ and $c_n \approx 0.40$, respectively. Figures 6 to 10 show the effect of angle of attack on the chordwise pressure distribution at various Mach numbers from 1.17 to 2.00.

Effect of Mach number.-- Pressure distributions at $c_n \approx 0.25$ are shown in figure 4 for Mach numbers from 0.65 to 2.00. The pressure distributions at $M = 0.65$, 0.85, and 0.90 are from reference 1 and are presented for the purpose of comparing the supersonic distributions from the present tests with those at subsonic Mach numbers from the previous tests.

The distribution at $M = 0.65$ in figure 4 is typical for the subsonic-type airfoil in subcritical flow. A negative pressure peak occurred at the leading edge of the upper surface, followed by a sharp pressure recovery. The high negative pressures at the peak resulted from the rapid expansion around the comparatively small leading-edge radius. Behind the negative pressure peak the local velocity increased and the pressure decreased to the 35-percent chord, the maximum thickness location, behind which a gradual pressure recovery occurred.

At $M = 0.85$ in figure 4 compressibility effects changed the distribution to that typical of transonic flow. The prominent leading-edge negative pressure peak disappeared; the pressure coefficients over the maximum thickness location were more negative on both surfaces than at $M = 0.65$; and over the forward part of the upper surface, the flow was supercritical terminated by a shock wave behind the maximum thickness location at about 50 percent chord.

The shock wave on the upper surface moved rearward to about 70 percent chord with increase in Mach number to 0.90, and the flow over the midsection of the lower surface was supersonic, probably terminated by a shock wave at about 60 percent chord.

At $M = 1.16$ the shock waves on both surfaces were still ahead of the trailing edge. Reference 2, which presents pressure distributions and schlieren photographs for a 45° sweptback wing-fuselage combination at Mach numbers up to 1.11, confirms the fact that for sweptback wings the shock wave does not reach the trailing edge until some supersonic Mach number, which undoubtedly depends upon the angle of sweep of the trailing edge.

As the Mach number increased to 2.00 the pressure coefficients on both surfaces became in general more positive, the shock wave on the upper surface moved rearward to the trailing edge, and the lower-surface shock appears to have become weaker, followed by an expansion over the trailing edge.

In general, the pressure distributions in figure 5 at $c_n \approx 0.40$ indicate the same trends with Mach number as those at $c_n \approx 0.25$.

Effect of angle of attack.— Pressure distributions at several values of wing-section normal-force coefficient for $M \approx 1.17, 1.37, 1.56, 1.85$, and 2.00 are shown in figures 6 to 10. The effects of angle of attack upon the pressure distributions at supersonic speeds were similar at all the above Mach numbers. On the upper surface the pressures were affected by the low values of the pressure coefficient for a vacuum

$$\left(P_{\text{vacuum}} = -\frac{2}{\gamma M^2} \right), \text{ thus limiting the extent to which the upper-surface}$$

pressures could expand as the angle of attack increased. As a result, the pressures ahead of the shock wave reached a near vacuum state at $\alpha \approx 12^\circ$ for $M \approx 1.37$ and at $\alpha \approx 9^\circ$ for $M \approx 1.56$, and the pressure coefficients from the leading edge to the shock position were nearly constant at these angles of attack.

At all Mach numbers presented the lower-surface pressure coefficients became more positive as the angle of attack increased.

Wing-Section Aerodynamic Characteristics

The variation of section normal-force coefficient with angle of attack for $M \approx 1.17, 1.37, 1.56, 1.85$, and 2.00 is shown in figure 11. The variation was almost linear, and a general decrease in slope occurred as the Mach number increased.

Figure 12 shows the variation of the upper- and lower-surface normal-force coefficients with c_n at $M \approx 1.17, 1.37$, and 1.56 . As previously mentioned, the upper-surface pressure coefficients were noticeably limited at the higher Mach numbers by the pressure coefficient for a vacuum. Figure 12 shows that as the angle of attack increased at $M \approx 1.37$ and 1.56 normal-force coefficient for the upper surface c_{n_U} reached a maximum value above which the increase in c_n came from the increase in pressure over the lower surface. This effect can also be seen in the pressure distributions of figure 8 at $M \approx 1.56$.

It may be seen that as c_n increased from 0.6 to 0.7 the upper-surface pressures remained essentially constant, whereas the lower-surface pressures became noticeably more positive.

Figure 13 shows the variation of pitching-moment coefficient with normal-force coefficient. The curves have a stable variation with c_n , and indicate that a decrease in slope occurred at $c_n \approx 0.4$.

Figure 14 shows the variation of the center of pressure with normal-force coefficient at $M \approx 1.17, 1.37, 1.56$, and 1.85 . The curves are limited to values of c_n above 0.2 since they go to infinity at $c_n = 0$. In general, the center of pressure moved rearward with increasing c_n .

Figure 15 shows the variation of the center of pressure with Mach number at $c_n \approx 0.25$. Included in the figure are data from reference 1. At $M = 0.83$ to 0.90 the center of pressure moved rearward from about 23 percent chord to about 35 percent chord. Supersonically the center of pressure moved rearward to about 41 percent chord at $M = 2.00$.

CONCLUSIONS

Results of pressure-distribution measurements over a wing midsemi-span station of the 35° sweptback wing of the Douglas D-558-II research airplane at supersonic Mach numbers indicate that:

1. As the angle of attack increased at the higher Mach numbers, the pressure coefficient for a vacuum limited the extent to which the upper-surface pressures could expand, and consequently most of the increase in normal-force coefficient at high angles of attack can be attributed to the increase in pressure over the lower surface.
2. At high subsonic speeds the center of pressure rapidly moved rearward with increasing Mach number. At supersonic speeds the center of pressure moved rearward both with increasing Mach number and with increasing angle of attack.

High-Speed Flight Station,
National Advisory Committee for Aeronautics,
Edwards, Calif., December 27, 1954.

REFERENCES

1. Peele, James R.: Flight-Determined Pressure Measurements Over the Wing of the Douglas D-558-II Research Airplane at Mach Numbers up to 1.14. NACA RM L54A07, 1954.
2. Whitcomb, Richard T., and Kelly, Thomas C.: A Study of the Flow Over a 45° Sweptback Wing-Fuselage Combination at Transonic Mach Numbers. NACA RM L52D01, 1952.

TABLE I

PHYSICAL CHARACTERISTICS OF THE DOUGLAS D-558-II AIRPLANE

Wing:

Root airfoil section (normal to 0.30 chord of unswept panel)	NACA 63-010
Tip airfoil section (normal to 0.30 chord of unswept panel)	NACA 63 ₁ -012
Total area, sq ft	175.0
Span, ft	25.0
Mean aerodynamic chord, in.	87.301
Root chord (parallel to plane of symmetry), in.	108.51
Extended tip chord (parallel to plane of symmetry), in.	61.18
Taper ratio	0.565
Aspect ratio	3.570
Sweep at 0.30 chord of unswept panel, deg	35.0
Sweep of leading edge, deg	38.8
Incidence at fuselage center line, deg	3.0
Dihedral, deg	-3.0
Geometric twist, deg	0

Horizontal tail:

Root airfoil section (normal to 0.30 chord of unswept panel)	NACA 63-010
Tip airfoil section (normal to 0.30 chord of unswept panel)	NACA 63-010
Total area, sq ft	39.9
Span, in.	143.6
Mean aerodynamic chord, in.	41.75
Root chord (parallel to plane of symmetry), in.	53.6
Extended tip chord (parallel to plane of symmetry), in.	26.8
Taper ratio	0.50
Aspect ratio	3.59
Sweep at 0.30 chord line of unswept panel, deg	40.0
Dihedral, deg	0

Vertical tail:

Airfoil section (normal to 0.30 chord of unswept panel)	NACA 63-010
Effective area, (area above root chord), sq ft	36.6
Height from fuselage reference line, in.	98.0
Root chord (chord 2 ^{1/4} in. above fuselage reference line), in.	116.8
Extended tip chord (parallel to fuselage reference line), in.	27.0
Sweep angle at 0.30 chord of unswept panel, deg	49.0

Fuselage:

Length, ft	42.0
Maximum diameter, in.	60.0
Fineness ratio	8.40

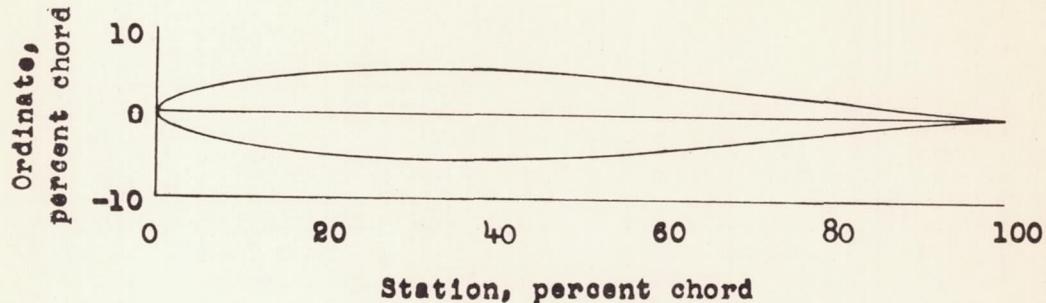
Power plant:

Rocket	LR8-RM-6
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Airplane weight, lb:

Full rocket fuel	15,787
No fuel	9,421

TABLE II
PROFILE AND ORDINATES OF THE ORIFICE STATION
(NACA 63₍₁₀₎-0(10.86) AIRFOIL)



[Stations and ordinates given in percent of local chord]

Station	Upper surface	Lower surface
0	0	0
.5	.900	-0.900
.75	1.090	-1.090
1.25	1.385	-1.385
2.5	1.907	-1.907
5.0	2.650	-2.650
7.5	3.204	-3.204
10	3.651	-3.651
15	4.337	-4.337
20	4.827	-4.827
25	5.162	-5.162
30	5.363	-5.363
35	5.430	-5.430
40	5.363	-5.363
45	5.176	-5.176
50	4.883	-4.883
55	4.496	-4.496
60	4.034	-4.034
65	3.512	-3.512
70	2.945	-2.945
75	2.352	-2.352
80	1.757	-1.757
85	1.182	-1.182
90	.656	-0.656
95	.232	-0.232
100	0	0
L.E. radius: 0.908		

TABLE III

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE

$$[M \approx 1.17]$$

Percent chord	Pressure coefficient					
	a	b	c	d	e	f
Upper surface	1.2	0.331	0.276	-0.133	-0.202	-0.198
	2.6	.216	.210	-.124	-.220	-.222
	5.0	.096	.093	-.061	-.159	-.198
	19.3	-.025	.023	-.266	-.272	-.272
	35.0	-.363	-.352	-.364	-.376	-.388
	51.2	-.146	-.141	-.346	-.324	-.355
	63.8	-.238	-.186	-.342	-.337	-.375
	70.8	-.218	-.212	-.319	-.315	-.297
	75.5	-.218	-.212	-.230	-.272	-.289
	80.0	-.193	-.187	-.230	-.254	-.246
	85.1	-.122	-.095	-.195	-.211	-.214
	94.6	-.001	-.001	-.061	-.046	-.090
Lower surface	0	0.762	0.740	0.742	0.683	0.724
	.7	.336	.457	.620	.642	.655
	3.6	.070	.090	.333	.364	.392
	5.8	.045	.044	.333	.330	.327
	9.1	-.122	-.095	.143	.215	.226
	18.9	-.001	-.001	.108	.093	.126
	30.8	-.262	-.232	-.021	.001	-.011
	34.4	-.218	-.212	-.124	-.115	-.073
	39.7	-.266	-.235	-.070	-.055	-.057
	43.6	-.193	-.187	-.124	-.116	-.132
	50.6	-.430	-.418	-.194	-.159	-.164
	56.1	-.314	-.212	-.159	-.150	-.148
	63.7	-.286	-.277	-.203	-.244	-.205
	70.6	-.266	-.212	-.221	-.168	-.181
	75.1	-.379	-.392	-.142	-.168	-.148
	84.8	-.170	-.141	-.159	-.115	-.131
	94.5	.070	-.002	.043	.047	.048
	98.6	.047	.046	.054	.041	.035
M	1.110	1.152	1.182	1.159	1.167	1.170
C_{N_A}	.012	0	.199	.217	.239	.256
α	-1.3°	-1.5°	1.7°	1.9°	2.3°	2.6°
c_n	-.030	-.040	.219	.244	.266	.285
$c_m c/4$.0112	.0144	-.0192	-.0218	-.0266	-.0256

TABLE III.- Continued

PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
OF THE D-558-II RESEARCH AIRPLANE

$$[M \approx 1.17]$$

Percent chord	Pressure coefficient					
	g	h	i	j	k	l
Upper surface	1.2	-0.252	-0.275	-0.308	-0.354	-0.434
	2.6	-0.278	-0.268	-0.312	-0.396	-0.409
	5.0	-0.261	-0.276	-0.312	-0.349	-0.440
	19.3	-0.334	-0.332	-0.359	-0.404	-0.432
	35.0	-0.416	-0.428	-0.438	-0.443	-0.535
	51.2	-0.408	-0.356	-0.383	-0.412	-0.417
	63.8	-0.370	-0.375	-0.378	-0.406	-0.433
	70.8	-0.326	-0.340	-0.343	-0.349	-0.369
	75.5	-0.294	-0.292	-0.312	-0.333	-0.314
	80.0	-0.260	-0.275	-0.271	-0.269	-0.296
	85.1	-0.237	-0.244	-0.225	-0.231	-0.250
	94.6	-0.066	-0.076	-0.090	-0.081	-0.117
Lower surface	0	0.735	0.675	0.660	0.654	0.605
	.7	.676	.708	.719	.740	.790
	3.6	.446	.429	.457	.516	.545
	5.8	.398	.421	.449	.492	.507
	9.1	.242	.244	.274	.312	.325
	18.9	.145	.156	.203	.186	.247
	30.8	.042	.047	.070	.132	.129
	34.4	-.050	-.044	-.034	-.003	.049
	39.7	-.009	-.004	.005	.029	.049
	43.6	-.132	-.077	-.044	-.020	-.008
	50.6	-.116	-.109	-.067	-.059	-.086
	56.1	-.131	-.132	-.129	-.097	-.053
	63.7	-.203	-.180	-.177	-.160	-.110
	70.6	-.139	-.156	-.114	-.081	-.030
	75.1	-.117	-.110	-.076	-.083	-.040
	84.8	-.131	-.124	-.098	-.058	-.045
	94.5	.077	.081	.081	.104	.117
	98.6	.031	.028	.029	.037	.049
M	1.173	1.180	1.183	1.183	1.176	1.165
C _{NA}	.286	.310	.349	.396	.452	.501
α	3.0°	3.4°	4.1°	4.8°	5.7°	6.5°
c _n	.324	.330	.371	.414	.470	.542
c _{m c/4}	-.0307	-.0326	-.0390	-.0445	-.0477	-.0627

TABLE III.- Concluded

PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
OF THE D-558-II RESEARCH AIRPLANE

$$[M \approx 1.17]$$

Percent chord	Pressure coefficient					
	m	n	o	p	q	r
Upper surface	1.2	-0.535	-0.570	-0.593	-0.617	-0.654
	2.6	-.548	-.582	-.598	-.639	-.669
	5.0	-.548	-.562	-.598	-.622	-.628
	19.3	-.548	-.555	-.614	-.614	-.612
	35.0	-.628	-.677	-.655	-.687	-.685
	51.2	-.460	-.555	-.502	-.501	-.713
	63.8	-.468	-.519	-.485	-.477	-.505
	70.8	-.388	-.434	-.445	-.493	-.474
	75.5	-.364	-.407	-.397	-.387	-.425
	80.0	-.346	-.424	-.370	-.384	-.341
	85.1	-.324	-.339	-.284	-.273	-.270
	94.6	-.132	-.144	-.131	-.160	-.156
Lower surface	0	0.542	0.477	0.521	0.455	0.451
	.7	.830	.788	.839	.841	.838
	3.6	.603	.727	.634	.626	.664
	5.8	.532	.516	.570	.562	.568
	9.1	.364	.349	.401	.441	.406
	18.9	.308	.302	.313	.278	.300
	30.8	.164	.172	.199	.197	.202
	34.4	.052	.052	.079	.073	.105
	39.7	.108	.113	.127	.108	.088
	43.6	.018	.016	.028	.025	.045
	50.6	-.045	-.090	-.059	-.040	-.011
	56.1	-.044	-.015	-.010	.027	.039
	63.7	-.070	-.065	-.029	-.017	.016
	70.6	.004	.045	.031	.027	.015
	75.1	-.031	-.032	-.037	-.025	.003
	84.8	.028	.012	.039	.059	.080
	94.5	.105	.143	.116	.121	.166
	98.6	.052	.032	.055	.051	.056
M	1.158	1.185	1.147	1.140	1.134	1.179
C _{N_A}	.548	.574	.601	.621	.648	.833
α	7.2°	7.6°	8.0°	8.4°	8.8°	-----
c _n	.580	.624	.629	.639	.697	.914
c _{m_c} /4	-.0698	-.0822	-.0739	-.0787	-.0979	-.1411

TABLE IV

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE

 $[M \approx 1.37]$

Percent chord	Pressure coefficient							
	a	b	c	d	e	f	g	
Upper surface	1.2	0.231	-0.216	---	-0.304	-0.316	-0.331	-0.359
	2.6	.185	-.266	---	-.321	-.318	-.365	-.393
	5.0	.185	-.299	---	-.337	-.318	-.365	-.408
	19.3	.016	-.316	---	-.385	-.397	-.412	-.424
	35.0	-.253	-.448	---	-.496	-.444	-.491	-.502
	51.2	-.152	-.547	---	-.544	-.539	-.491	-.533
	63.8	-.233	-.425	---	-.464	-.492	-.475	-.565
	70.8	-.152	-.497	---	-.480	-.444	-.491	-.533
	75.5	-.135	-.349	---	-.417	-.413	-.428	-.440
	80.0	-.135	-.396	---	-.398	-.410	-.425	-.437
	85.1	-.135	-.250	---	-.298	-.318	-.286	-.362
	94.6	-.034	-.233	---	-.257	-.239	-.223	-.237
	0	0.842	0.651	---	0.558	0.553	0.553	0.547
	.7	.574	.779	---	.718	.836	.850	.791
Lower surface	3.6	.264	.403	---	.451	.494	.556	.535
	5.8	.231	.338	---	.373	.463	.509	.535
	9.1	.084	.311	---	.300	.345	.360	.451
	18.9	.117	.245	---	.252	.266	.282	.326
	30.8	-.035	.058	---	.102	.070	.101	.191
	34.4	-.085	-.019	---	-.002	.045	.061	.091
	39.7	-.119	.031	---	.014	.077	.108	.138
	43.6	-.101	-.053	---	-.020	.026	.042	.042
	50.6	-.251	-.167	---	-.146	-.098	-.067	.138
	56.1	-.135	-.118	---	-.098	-.097	-.081	.042
	63.7	-.167	-.152	---	-.116	-.115	-.068	-.036
	70.6	-.119	-.134	---	-.098	-.081	-.081	-.034
	75.1	-.216	-.135	---	-.085	-.084	-.068	-.068
	84.8	-.135	-.134	---	-.098	-.129	-.049	-.034
	94.5	-.001	.031	---	.074	.073	.074	-.037
	98.6	.016	-.002	---	-.002	-.002	.045	-.080
M	1.390	1.351	---	1.371	1.376	1.377	1.378	
C_{NA}	.074	.382	---	.448	.499	.546	.593	
α	-.1°	4.8°	---	5.9°	6.7°	7.4°	8.2°	
c_n	.055	.406	---	.463	.474	.504	.572	
$c_m c/4$	-.0022	-.0554	---	-.0701	-.0678	-.0749	-.0870	

TABLE IV.- Concluded

 PRESSURE COEFFICIENTS FOR A MIDSEMISSPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE
 $[M \approx 1.37]$

Percent chord	Pressure coefficient							
	h	i	j	k	l	m	n	
Upper surface	1.2	-0.390	-0.467	-0.516	-0.499	-0.517	-0.614	-0.602
	2.6	-.393	-.424	-.488	-.488	-.506	-.556	-.575
	5.0	-.377	-.424	-.535	-.519	-.537	-.620	-.575
	19.3	-.424	-.486	-.551	-.519	-.569	-.635	-.591
	35.0	-.533	-.596	-.614	-.566	-.632	-.699	-.657
	51.2	-.518	-.533	-.661	-.645	-.616	-.635	-.657
	63.8	-.518	-.596	-.629	-.645	-.616	-.667	-.673
	70.8	-.518	-.533	-.661	-.660	-.647	-.651	-.608
	75.5	-.424	-.440	-.535	-.551	-.569	-.572	-.542
	80.0	-.436	-.452	-.547	-.500	-.533	-.567	-.553
	85.1	-.330	-.330	-.457	-.425	-.443	-.493	-.428
	94.6	-.268	-.330	-.410	-.425	-.396	-.382	-.378
Lower surface	0	0.473	0.421	0.388	0.420	0.313	0.226	0.338
	.7	.825	.826	.901	.951	.919	.820	1.043
	3.6	.597	.581	.614	.661	.695	.699	.854
	5.8	.582	.612	.598	.661	.679	.683	.773
	9.1	.451	.435	.483	.546	.533	.536	.604
	18.9	.357	.372	.373	.422	.548	.520	.588
	30.8	.207	.283	.283	.345	.347	.348	.443
	34.4	.170	.138	.170	.170	.250	.219	.342
	39.7	.123	.169	.154	.186	.265	.235	.310
	43.6	.088	.057	.103	.150	.182	.198	.272
	50.6	-.020	.026	-.021	.011	.089	.105	.158
	56.1	-.018	.044	.013	.014	.076	.093	.178
	63.7	-.006	-.037	-.008	.024	.070	.101	.139
	70.6	-.018	-.018	.013	.029	.108	.156	.195
	75.1	.009	.024	.038	.085	.116	.255	.203
	84.8	-.018	.013	-.018	.029	.108	.140	.195
	94.5	.150	.165	.196	.212	.261	.245	.320
	98.6	.091	.060	.091	.076	.124	.124	.146
M	1.378	1.378	1.373	1.373	1.368	1.363	1.345	
C _{NA}	.636	.690	.756	.799	.855	.906	.965	
α	9.1°	10.0°	11.2°	11.9°	12.8°	13.7°	14.7°	
c _n	.599	.660	.749	.770	.842	.894	.930	
c _{m c/4}	-.0998	-.1120	-.1360	-.1389	-.1514	-.1677	-.1678	

TABLE V

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE

 $[M \approx 1.56]$

Percent chord	Pressure coefficient					
	a	b	c	d	e	f
Upper surface	1.2	0.255	0.074	0.017	-0.025	-0.035
	2.6	.236	.043	-.035	-.045	-.044
	5.0	.129	-.024	-.100	-.110	-.119
	19.3	.023	-.113	-.188	-.154	-.172
	35.0	-.189	-.258	-.297	-.306	-.310
	51.2	-.119	-.247	-.352	-.306	-.332
	63.8	-.186	-.314	-.379	-.344	-.348
	70.8	-.189	-.224	-.308	-.262	-.310
	75.5	-.130	-.280	-.352	-.317	-.332
	80.0	-.129	-.224	-.317	-.293	-.319
	85.1	-.130	-.224	-.286	-.262	-.257
	94.6	-.060	-.189	-.221	-.176	-.215
	0	0.889	0.898	0.951	0.755	0.789
	.7	.668	.614	.668	.709	.790
Lower surface	3.6	.372	.448	.503	.544	.586
	5.8	.337	.334	.395	.437	.470
	9.1	.200	.244	.271	.335	.350
	18.9	.212	.166	.173	.205	.265
	30.8	.045	.104	.079	.144	.141
	34.4	-.036	-.013	-.046	.020	.041
	39.7	-.024	-.021	-.046	.064	.073
	43.6	-.025	-.091	-.069	-.025	-.014
	50.6	-.153	-.102	-.123	-.057	-.035
	56.1	-.095	-.124	-.166	-.099	-.055
	63.7	-.117	-.124	-.123	-.079	-.046
	70.6	-.083	-.091	-.155	-.077	-.066
	75.1	-.151	-.102	-.113	-.058	-.036
	84.8	-.071	-.124	-.166	-.143	-.087
	94.5	.010	-.014	-.036	.018	.049
	98.6	0	-.091	-.111	-.056	-.044
M	1.581	1.585	1.585	1.585	1.589	1.587
C _{NA}	.107	.200	.251	.301	.351	.390
α	.6°	2.2°	3.0°	3.9°	4.7°	5.4°
c _n	.109	.222	.274	.305	.357	.375
c _{m c/4}	-.0109	-.0310	-.0397	-.0422	-.0554	-.0608

TABLE V.- Concluded

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE

$$[M \approx 1.56]$$

Percent chord	Pressure coefficient					
	g	h	i	j	k	l
Upper surface	1.2	-0.195	-0.203	-0.285	-0.311	-0.331
	2.6	-.195	-.204	-.255	-.282	-.323
	5.0	-.227	-.236	-.329	-.354	-.375
	19.3	-.270	-.289	-.329	-.344	-.375
	35.0	-.399	-.385	-.434	-.427	-.479
	51.2	-.388	-.385	-.435	-.437	-.448
	63.8	-.445	-.410	-.469	-.481	-.491
	70.8	-.366	-.364	-.445	-.416	-.448
	75.5	-.399	-.407	-.456	-.458	-.448
	80.0	-.322	-.340	-.379	-.372	-.372
	85.1	-.324	-.300	-.382	-.365	-.385
	94.6	-.195	-.183	-.255	-.244	-.271
Lower surface	0	0.651	0.704	0.604	0.580	0.546
	.7	.751	.827	.810	.853	.866
	3.6	.631	.702	.663	.692	.723
	5.8	.557	.587	.559	.611	.641
	9.1	.362	.457	.452	.506	.537
	18.9	.319	.404	.357	.402	.381
	30.8	.161	.245	.210	.258	.308
	34.4	.052	.126	.114	.195	.195
	39.7	.105	.201	.219	.216	.257
	43.6	.017	.070	.069	.099	.109
	50.6	-.025	.038	.059	.043	.109
	56.1	-.002	.041	.030	.029	.081
	63.7	-.048	-.005	.025	.045	.045
	70.6	-.056	-.002	-.002	.040	.029
	75.1	-.027	.016	.015	.035	.035
	84.8	-.107	-.055	-.065	-.002	-.002
	94.5	.033	.113	.121	.140	.139
	98.6	-.023	.052	.051	.102	.071
M	1.563	1.555	1.549	1.552	1.544	1.538
C_{NA}	.453	.497	.547	.603	.641	.699
α	6.7°	7.5°	8.5°	9.6°	10.3°	11.4°
c_n	.432	.500	.548	.578	.626	.686
$c_m c/4$	-.0624	-.0704	-.0893	-.0915	-.0982	-.1171

TABLE VI

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE

$$[M \approx 1.77]$$

	Percent chord	Pressure coefficient					
		a	b	c	d	e	f
Upper surface	1.2	0.251	0.153	0.109	0.072	-0.014	-0.075
	2.6	.180	.088	.049	.029	-.038	-.100
	5.0	.142	.054	.026	-.020	-.076	-.112
	19.3	-.023	-.059	-.086	-.107	-.183	-.193
	35.0	-.189	-.194	-.198	-.229	-.227	-.249
	51.2	-.136	-.194	-.210	-.244	-.270	-.274
	63.8	-.186	-.247	-.229	-.273	-.278	-.293
	70.8	-.197	-.172	-.229	-.274	-.302	-.311
	75.5	-.174	-.262	-.198	-.267	-.296	-.299
	80.0	-.188	-.193	-.185	-.220	-.293	-.296
	85.1	-.144	-.206	-.175	-.188	-.195	-.193
	94.6	-.106	-.070	-.109	-.138	-.164	-.187
	0	0.876	0.845	0.910	0.876	0.810	0.772
	.7	.608	.733	.751	.758	.838	.885
Lower surface	3.6	.392	.477	.526	.541	.618	.648
	5.8	.325	.354	.453	.439	.568	.654
	9.1	.210	.269	.327	.329	.476	.496
	18.9	.195	.201	.258	.234	.313	.390
	30.8	.071	.106	.144	.163	.267	.294
	34.4	.022	.066	.080	.067	.112	.179
	39.7	-.023	-.059	.096	.094	.200	.229
	43.6	-.024	.030	.055	.028	.116	.146
	50.6	-.143	-.070	-.025	-.029	.066	.072
	56.1	-.099	-.047	-.032	-.024	.056	.049
	63.7	-.098	-.104	-.033	-.040	.034	.070
	70.6	-.099	-.025	-.028	-.094	.056	.074
	75.1	-.127	-.093	-.052	-.044	.052	.070
	84.8	-.084	-.047	-.055	-.066	.030	.018
	94.5	-.032	-.015	.018	.005	.097	.115
	98.6	-.054	.032	-.005	-.016	.087	.092
		M	1.794	1.778	1.793	1.774	1.785
		C_{NA}	.119	.195	.231	.264	.398
		α	1.5°	2.2°	3.6°	4.2°	6.1°
		c_n	.123	.202	.246	.274	.397
		$c_m c/4$	-.0160	-.0291	-.0317	-.0397	-.0675
							-.0707

TABLE VII

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE

 $[M \approx 1.85]$

Percent chord	Pressure coefficient								
	a	b	c	d	e	f	g	h	
Upper surface	1.2	0.357	0.349	0.236	0.262	0.211	0.075	0.060	0.023
	2.6	.269	.296	.187	.208	.150	.038	.043	-.020
	5.0	.286	.238	.142	.143	.114	-.008	-.013	-.026
	19.3	.024	.040	-.031	-.008	-.051	-.127	-.095	-.152
	35.0	-.077	-.075	-.121	-.138	-.152	-.219	-.183	-.196
	51.2	-.119	-.108	-.166	-.131	-.181	-.292	-.208	-.246
	63.8	-.126	-.147	-.171	-.164	-.199	-.294	-.242	-.266
	70.8	-.128	-.133	-.159	-.196	-.202	-.272	-.240	-.258
	75.5	-.144	-.133	-.136	-.196	-.217	-.286	-.258	-.277
	80.0	-.185	-.189	-.165	-.194	-.201	-.231	-.200	-.238
	85.1	-.085	-.075	-.114	-.123	-.138	-.206	-.152	-.183
	94.6	-.094	-.091	-.084	-.095	-.116	-.193	-.114	-.139
Lower surface	0	0.904	0.909	0.832	0.955	0.937	0.852	0.847	0.848
	.7	.492	.544	.557	.663	.735	.710	.804	.826
	3.6	.198	.292	.332	.440	.446	.453	.594	.606
	5.8	.257	.333	.303	.390	.396	.395	.495	.550
	9.1	.168	.222	.240	.288	.337	.328	.420	.445
	18.9	.041	.123	.112	.158	.157	.183	.263	.257
	30.8	-.019	.054	.078	.117	.158	.131	.218	.242
	34.4	-.052	-.001	-.008	.006	.064	-.002	.112	.112
	39.7	-.026	-.001	-.001	.042	.085	.031	.163	.150
	43.6	-.085	-.001	-.032	.012	.019	.029	.085	.085
	50.6	-.110	-.099	-.113	-.094	-.030	-.042	.060	.054
	56.1	-.170	-.141	-.099	-.095	-.066	-.087	-.013	.012
	63.7	-.168	-.131	-.127	-.094	-.087	-.101	-.014	-.009
	70.6	-.102	-.108	-.099	-.073	-.058	-.054	.012	.037
	75.1	-.159	-.131	-.105	-.101	-.080	-.088	.004	.022
	84.8	-.119	-.058	-.054	-.066	-.066	-.087	-.001	.012
	94.5	-.069	-.001	-.024	-.030	-.009	-.049	.054	.079
	98.6	-.102	-.058	-.046	-.022	-.022	-.034	.050	.043
M	1.847	1.850	1.870	1.864	1.852	1.836	1.838	1.821	
C_{NA}	-.004	.054	.103	.135	.196	.245	.305	.346	
α	-1.4°	$-.2^\circ$	$.7^\circ$	1.3°	2.5°	3.4°	4.6°	5.4°	
c_n	.007	.054	.099	.130	.182	.252	.302	.337	
$c_m c/4$	-.0029	-.0106	-.0128	-.0154	-.0253	-.0381	-.0445	-.0547	

TABLE VIII

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE
 $[M \approx 2.0]$

Percent chord	Pressure coefficient					
	a	b	c	d	e	f
Upper surface	1.2	0.377	0.337	0.347	0.175	0.168
	2.6	.271	.245	.251	.103	.096
	5.0	.240	.208	.219	.089	.061
	19.3	.044	.027	.022	-.048	-.083
	35.0	-.095	-.103	-.107	-.178	-.180
	51.2	-.099	-.107	-.107	-.185	-.194
	63.8	-.138	-.165	-.151	-.223	-.231
	70.8	-.126	-.121	-.125	-.206	-.228
	75.5	-.149	-.168	-.157	-.212	-.207
	80.0	-.143	-.134	-.143	-.184	-.213
	85.1	-.117	-.149	-.135	-.199	-.200
	94.6	-.068	-.061	-.066	-.103	-.131
						-.124
Lower surface	0	0.908	0.912	0.934	0.912	0.901
	.7	.509	.534	.533	.757	.799
	3.6	.280	.305	.311	.492	.488
	5.8	.240	.246	.270	.384	.420
	9.1	.168	.171	.178	.294	.323
	18.9	.079	.097	.104	.212	.206
	30.8	.010	.020	.037	.131	.165
	34.4	-.046	-.028	-.024	.075	.055
	39.7	-.024	-.024	-.006	.027	.020
	43.6	-.081	-.084	-.061	.019	.046
	50.6	-.099	-.107	-.093	-.001	.012
	56.1	-.104	-.117	-.098	-.007	.055
	63.7	-.120	-.116	-.110	-.062	-.043
	70.6	-.105	-.112	-.112	0	-.007
	75.1	-.155	-.147	-.142	-.069	-.057
	84.8	-.122	-.117	-.130	-.027	-.028
	94.5	-.064	-.043	-.047	-.008	.005
	98.6	-.091	-.103	-.084	-.007	-.001
	M	1.955	1.958	1.954	2.001	2.001
	C_{NA}	.006	.021	.033	.183	.210
	α	-1.4°	-1.1°	$-.8^\circ$	2.6°	3.2°
	c_n	.022	.039	.050	.210	.238
	$c_m c/4$	-.0045	-.0045	-.0054	-.0336	-.0390
						-.0397

TABLE IX

 PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
 OF THE D-558-II RESEARCH AIRPLANE

$$\left[c_n \approx 0.09 \right]$$

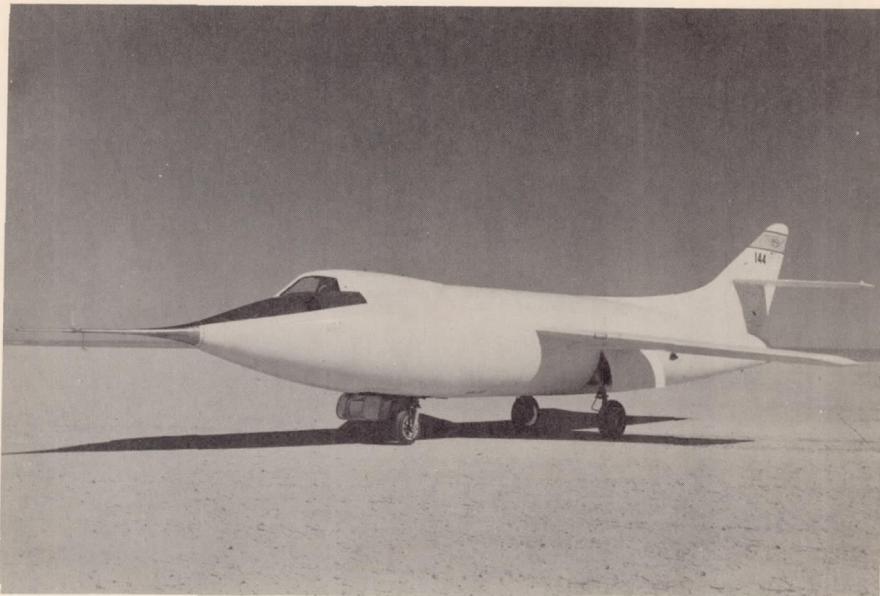
Percent chord	Pressure coefficient					
	a	b	c	d	e	f
Upper surface	1.2	0.241	0.244	0.231	0.310	0.231
	2.6	.200	.186	.176	.315	.185
	5.0	.044	.095	.137	.141	.185
	19.3	.021	-.042	-.020	.042	.016
	35.0	-.336	-.312	-.296	-.280	-.253
	51.2	-.180	-.188	-.178	-.206	-.152
	63.8	-.242	-.266	-.252	-.227	-.233
	70.8	-.202	-.188	-.178	-.206	-.152
	75.5	-.180	-.167	-.158	-.206	-.135
	80.0	-.179	-.166	-.157	-.102	-.135
	85.1	-.157	-.167	-.158	-.156	-.135
	94.6	-.023	-.022	-.040	-.057	-.034
						-.071
Lower surface	0	0.707	0.728	0.960	0.745	0.842
	.7	.487	.521	.560	.474	.574
	3.6	.218	.224	.270	.236	.264
	5.8	.152	.162	.212	.163	.231
	9.1	-.023	.081	.058	.017	.084
	18.9	.044	.082	.078	-.008	.117
	30.8	-.134	-.084	-.076	-.082	-.035
	34.4	-.235	-.146	-.138	-.206	-.085
	39.7	-.235	-.167	-.158	-.156	-.119
	43.6	-.179	-.145	-.138	-.157	-.101
	50.6	-.377	-.330	-.293	-.204	-.251
	56.1	-.180	-.167	-.158	-.057	-.135
	63.7	-.221	-.205	-.194	-.082	-.167
	70.6	-.157	-.146	-.138	-.107	-.119
	75.1	-.374	-.246	-.252	-.227	-.216
	84.8	-.113	-.084	-.119	-.156	-.135
	94.5	.020	.039	.017	.016	-.001
	98.6	.044	.041	.039	.067	.016
						.028
M	1.201	1.256	1.293	1.293	1.390	1.490
C_{NA}	.062	.078	.083	.061	.074	.099
α	-.6°	-.3°	-.2°	-.5°	0°	.5°
c_n	.032	.066	.055	.045	.055	.104
$c_m c/4$	-.0019	-.0070	-.0038	-.0163	-.0022	-.0109

TABLE IX.- Concluded

PRESSURE COEFFICIENTS FOR A MIDSEMISPAN STATION ON THE WING
OF THE D-558-II RESEARCH AIRPLANE

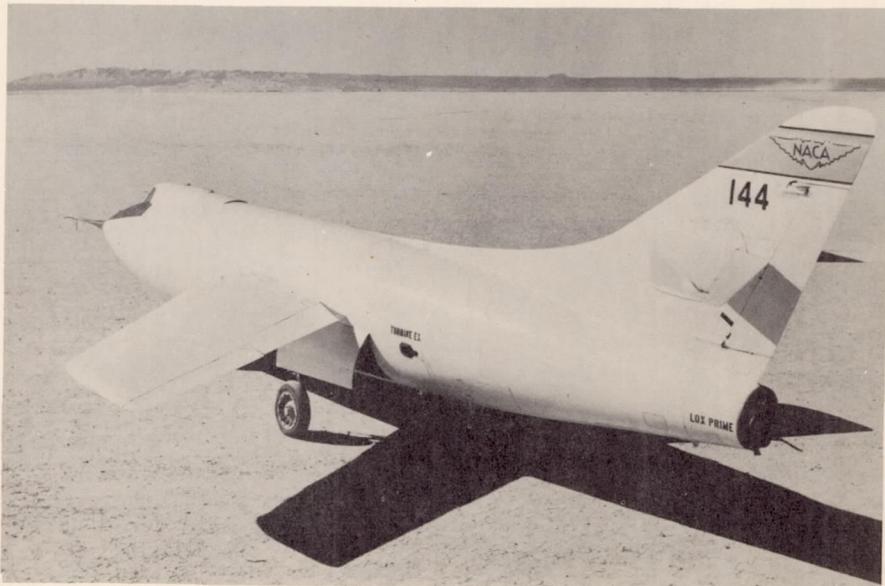
$$\left[c_n \approx 0.09 \right]$$

Percent chord	Pressure coefficient				
	g	h	i	j	k
Upper surface	1.2	0.255	0.251	0.251	0.236
	2.6	.236	.164	.180	.187
	5.0	.129	.136	.142	.142
	19.3	.023	-.029	-.023	-.031
	35.0	-.189	-.203	-.189	-.121
	51.2	-.119	-.138	-.136	-.166
	63.8	-.186	-.181	-.186	-.171
	70.8	-.189	-.193	-.197	-.159
	75.5	-.130	-.148	-.174	-.136
	80.0	-.129	-.210	-.188	-.165
	85.1	-.130	-.138	-.144	-.114
	94.6	-.060	-.093	-.106	-.084
Lower surface	0	0.889	0.894	0.876	0.832
	.7	.668	.603	.608	.557
	3.6	.372	.378	.392	.332
	5.8	.337	.351	.325	.303
	9.1	.200	.246	.210	.240
	18.9	.212	.155	.195	.112
	30.8	.045	.086	.071	.078
	34.4	-.036	-.047	.022	-.008
	39.7	-.024	-.010	-.023	-.001
	43.6	-.025	-.020	-.024	-.032
	50.6	-.153	-.119	-.143	-.113
	56.1	-.095	-.074	-.099	-.099
	63.7	-.117	-.101	-.098	-.127
	70.6	-.083	-.111	-.099	-.099
	75.1	-.151	-.137	-.127	-.105
	84.8	-.071	-.102	-.084	-.054
	94.5	.010	-.011	-.032	-.024
	98.6	0	-.029	-.054	-.046
M	1.581	1.708	1.794	1.870	1.889
C_{NA}	.107	.107	.119	.103	.094
α	.6°	.7°	1.0°	.7°	.5°
c_n	.109	.123	.123	.099	.097
$c_m c_{1/4}$	-.0109	-.0131	-.0160	-.0128	-.0112



(a) Three-quarter front view.

L-87501



(b) Three-quarter rear view.

L-87502

Figure 1.- Photographs of the Douglas D-558-II research airplane.

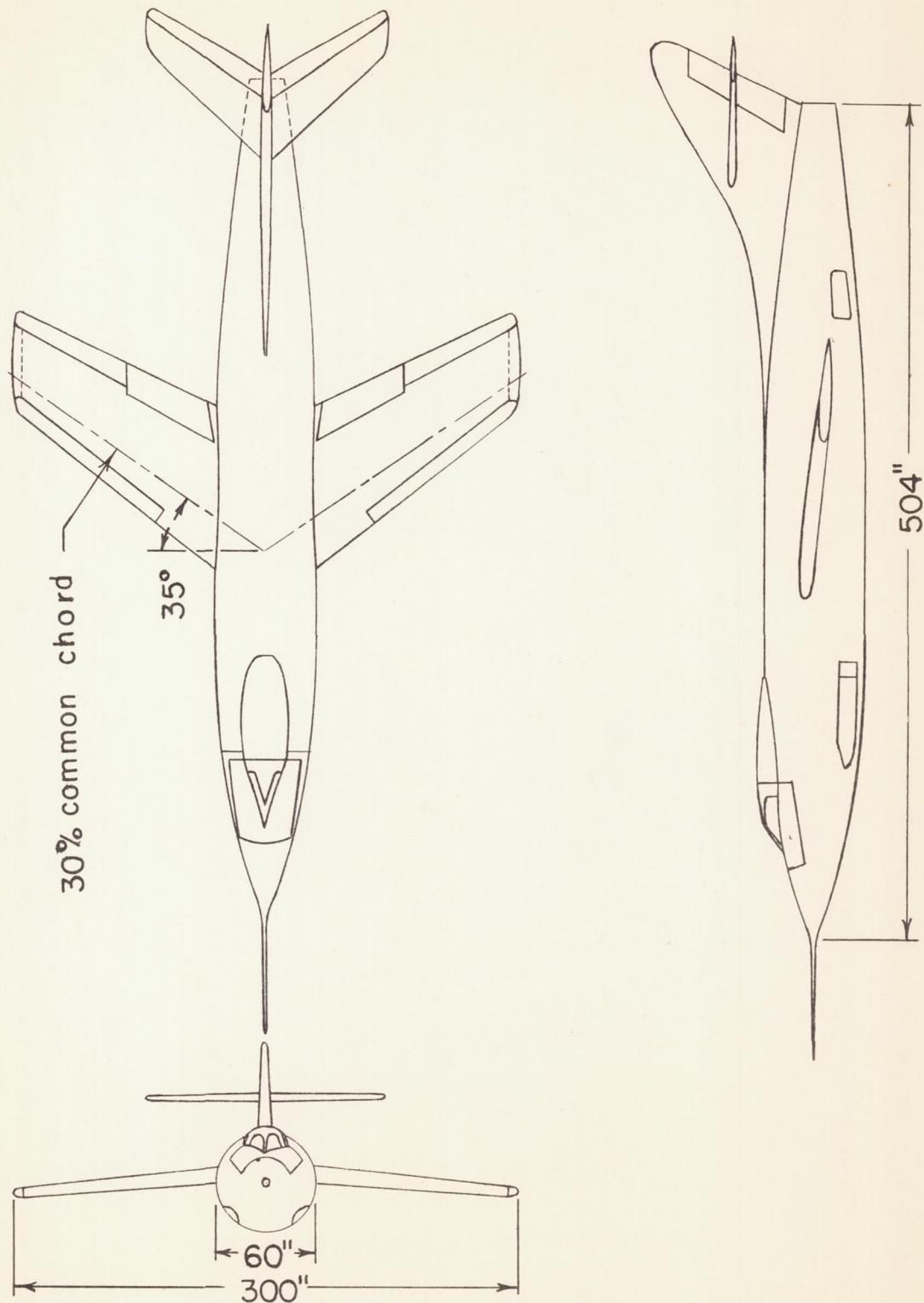


Figure 2.- Three-view drawing of the Douglas D-558-II research airplane.

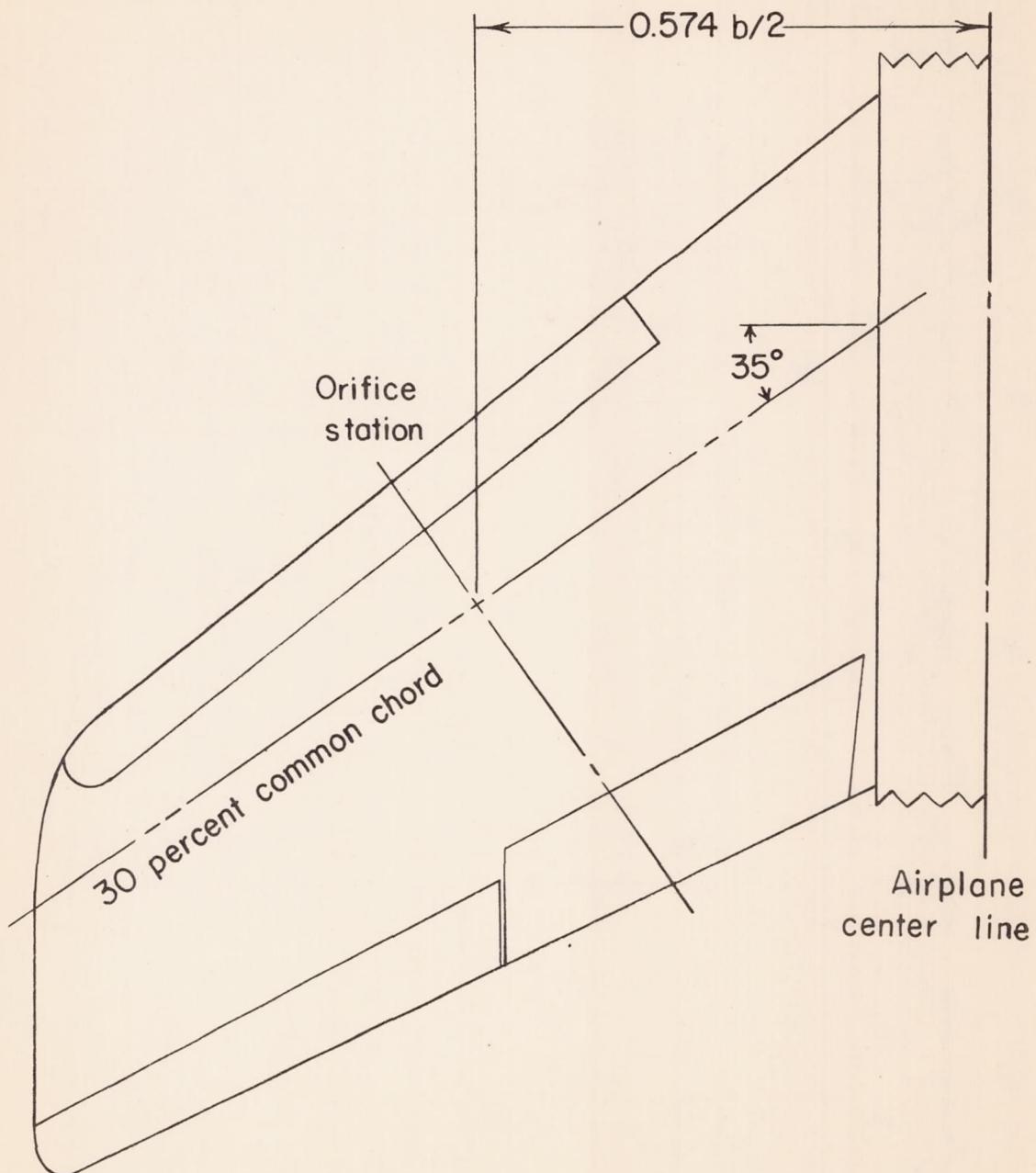


Figure 3.- Location of static-pressure orifices.

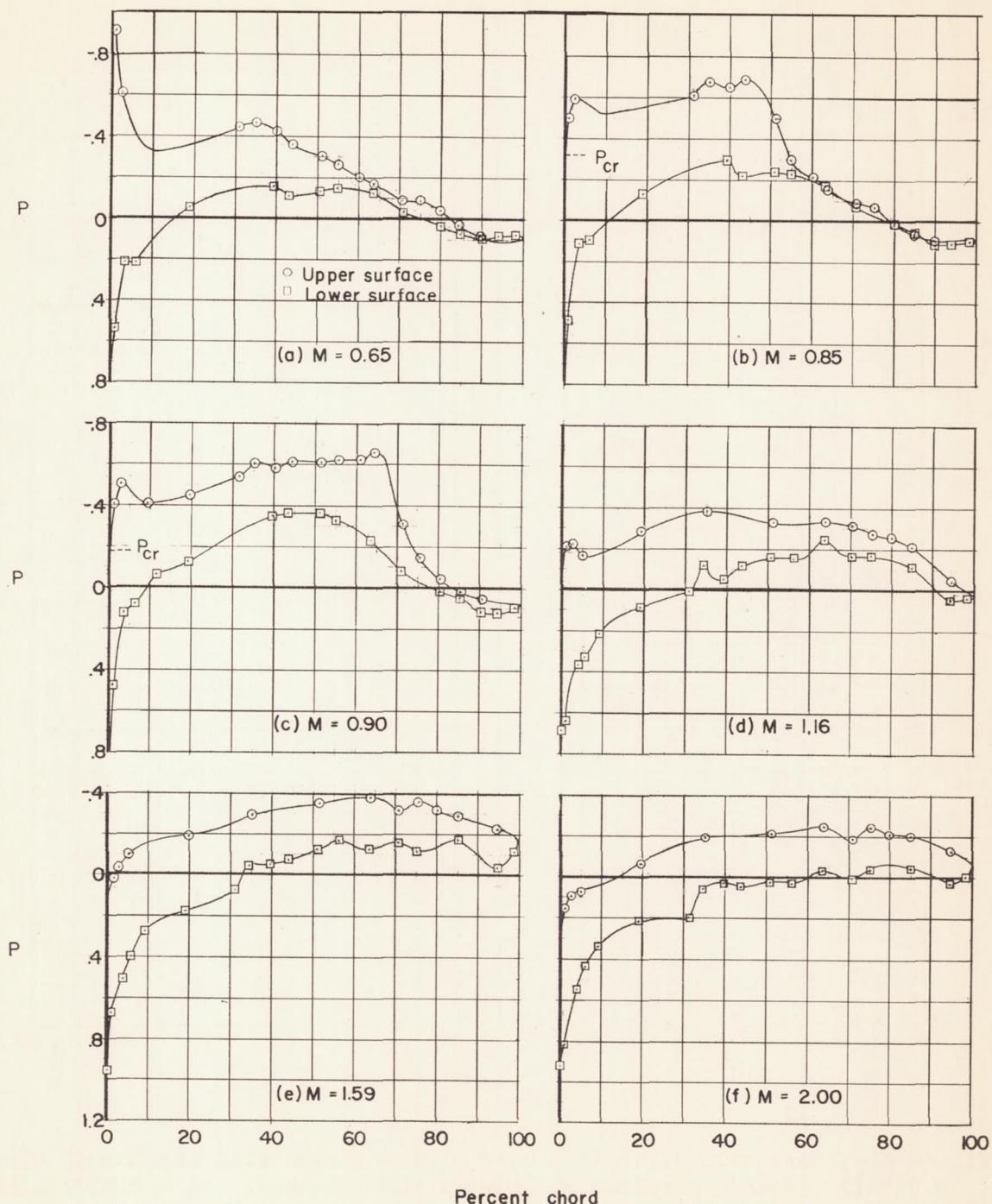


Figure 4.- Pressure distribution over a midsemispan wing station of the D-558-II research airplane at several Mach numbers. $c_n = 0.25 \pm 0.04$.

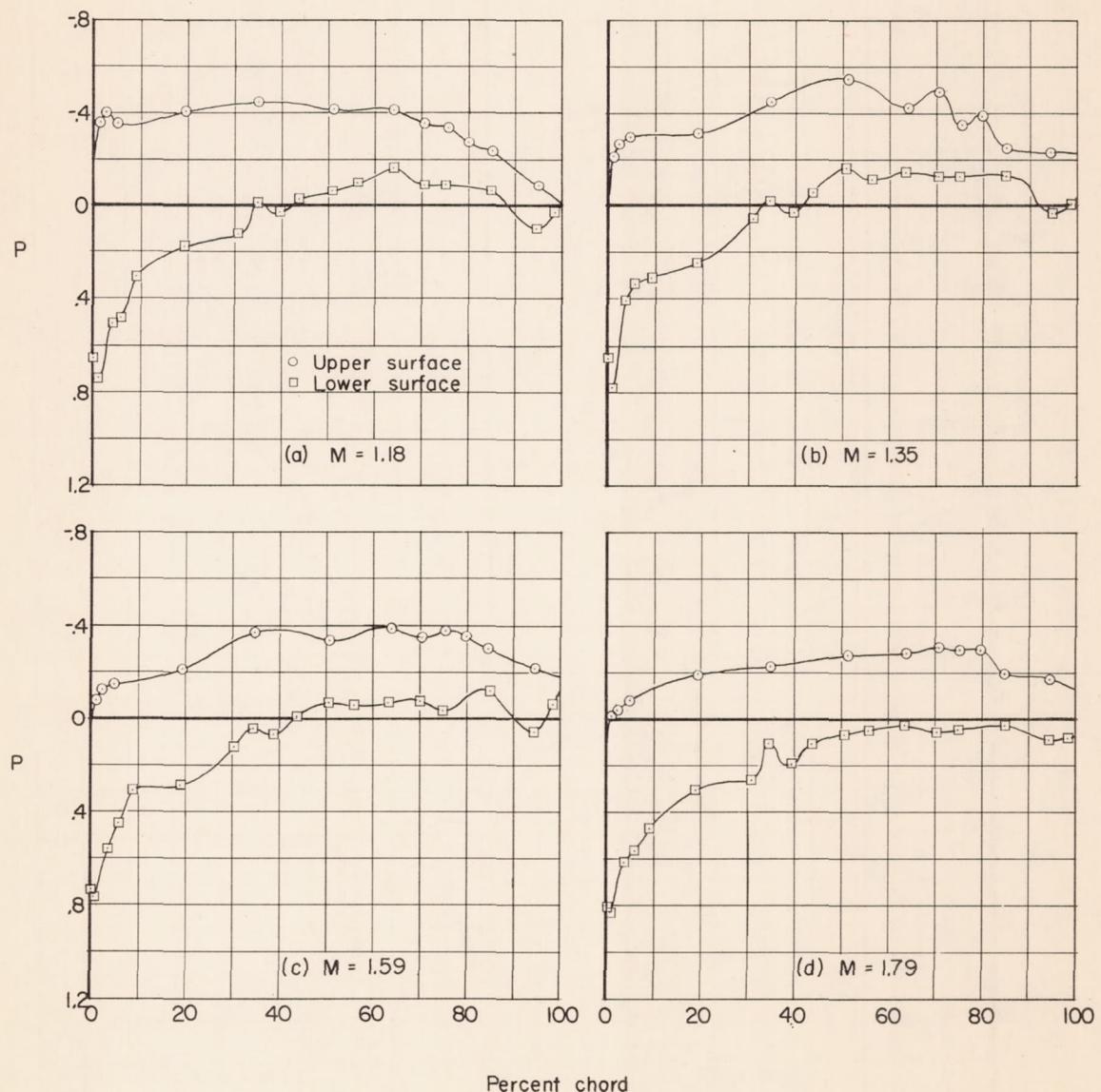


Figure 5.- Pressure distribution over a midsemispan wing station of the D-558-II research airplane at several Mach numbers. $c_n = 0.40 \pm 0.02$.

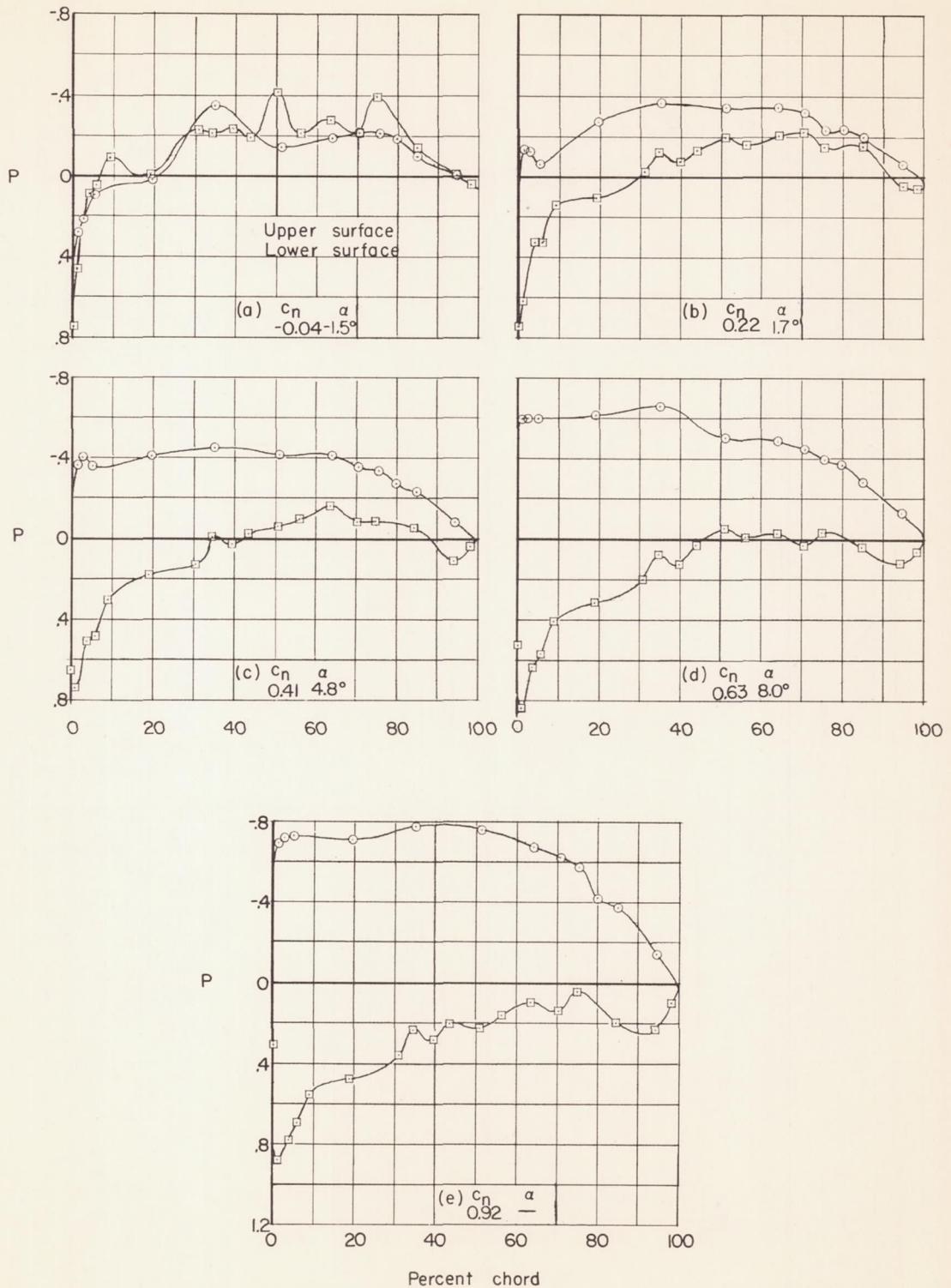


Figure 6.- Pressure distribution over a midsemispan wing station of the D-558-II research airplane at several values of wing section normal-force coefficient. $M = 1.17 \pm 0.03$.

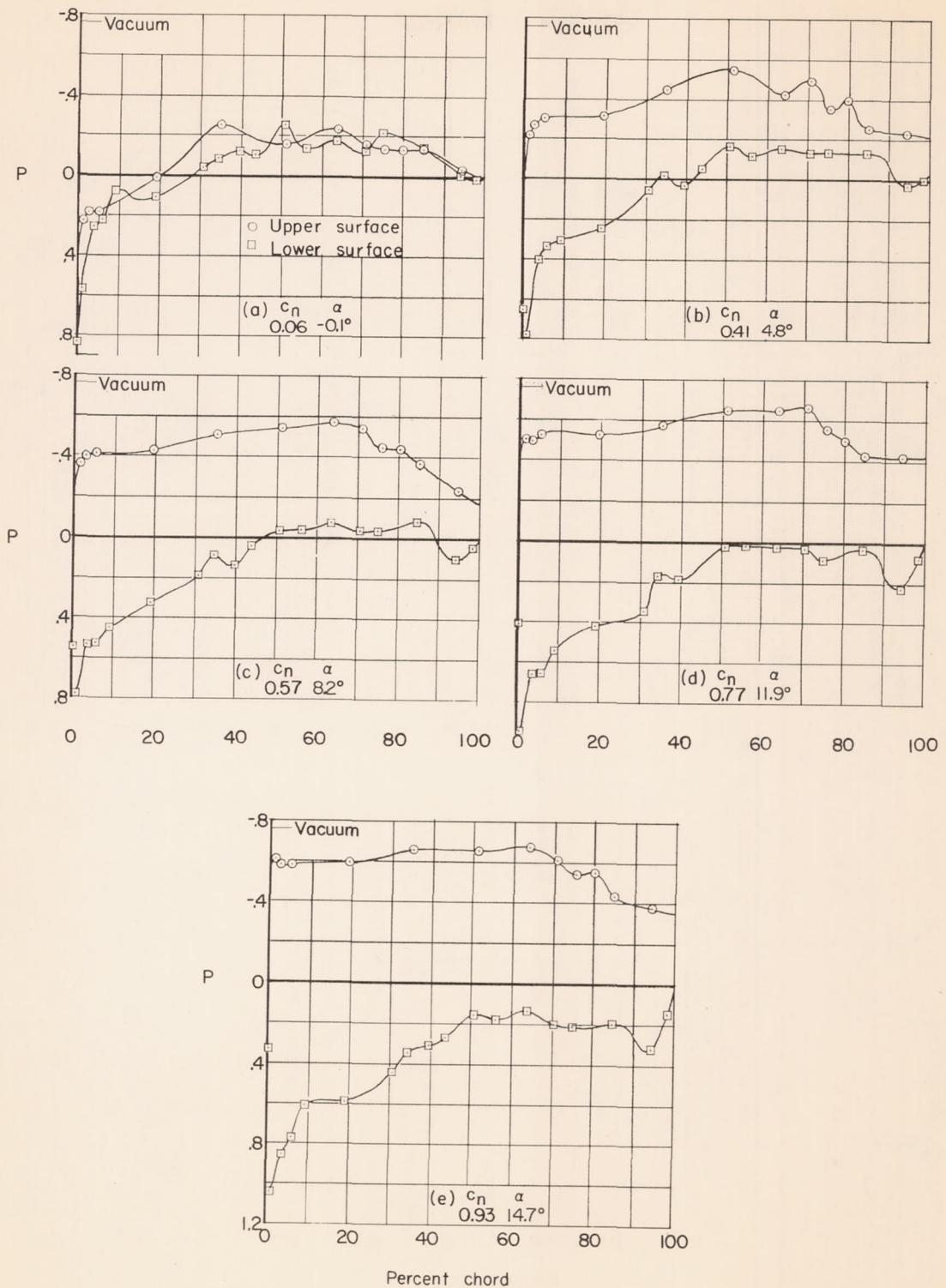


Figure 7.- Pressure distribution over a midsemispan wing station of the D-558-II research airplane at several values of wing section normal-force coefficient. $M = 1.37 \pm 0.03$.

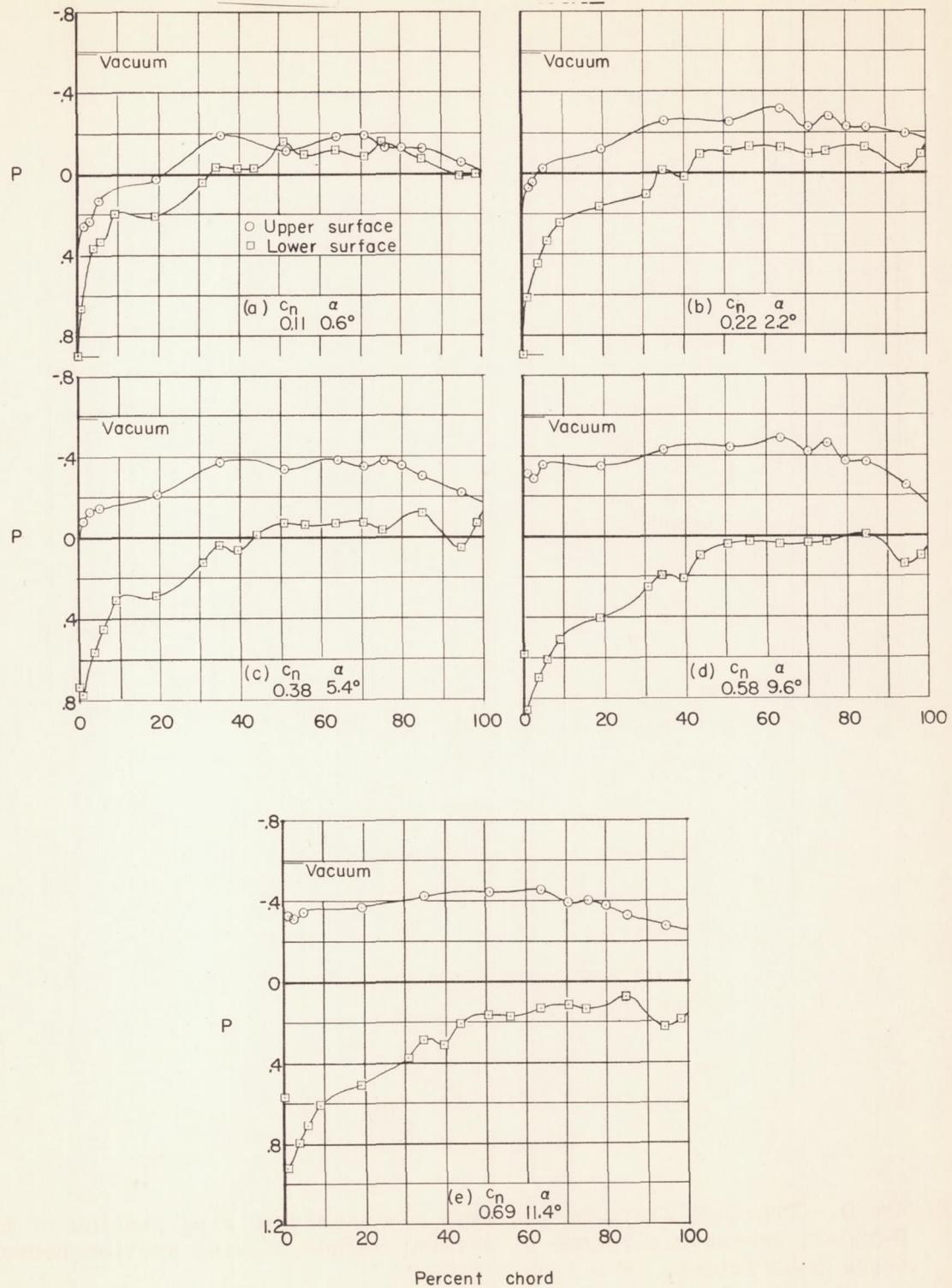


Figure 8.- Pressure distribution over a midsemispan wing station of the D-558-II research airplane at several values of wing section normal-force coefficient. $M = 1.56 \pm 0.03$.

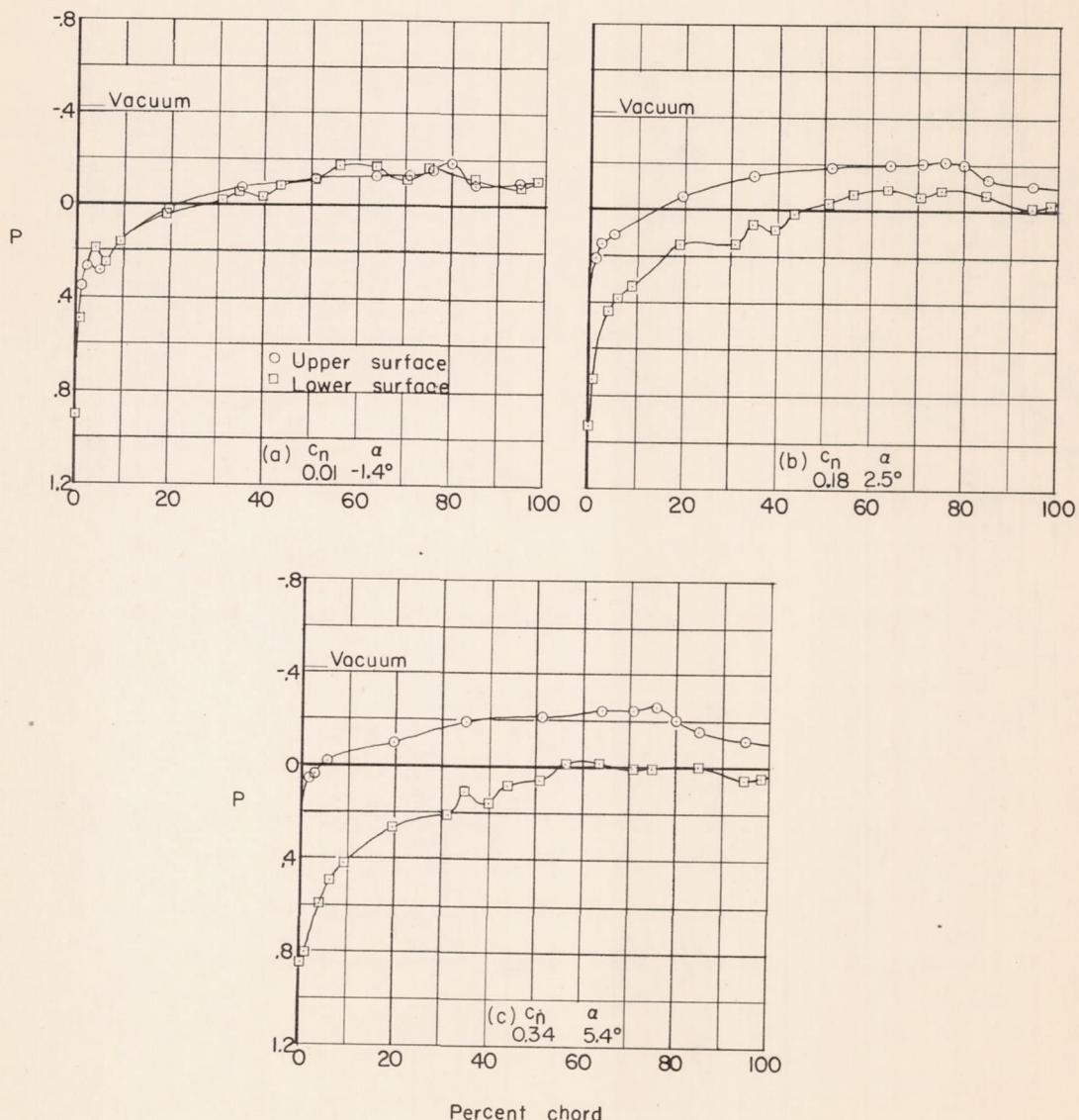


Figure 9.- Pressure distribution over a midsemispan wing station of the D-558-II research airplane at several values of wing section normal-force coefficient. $M = 1.85 \pm 0.03$.

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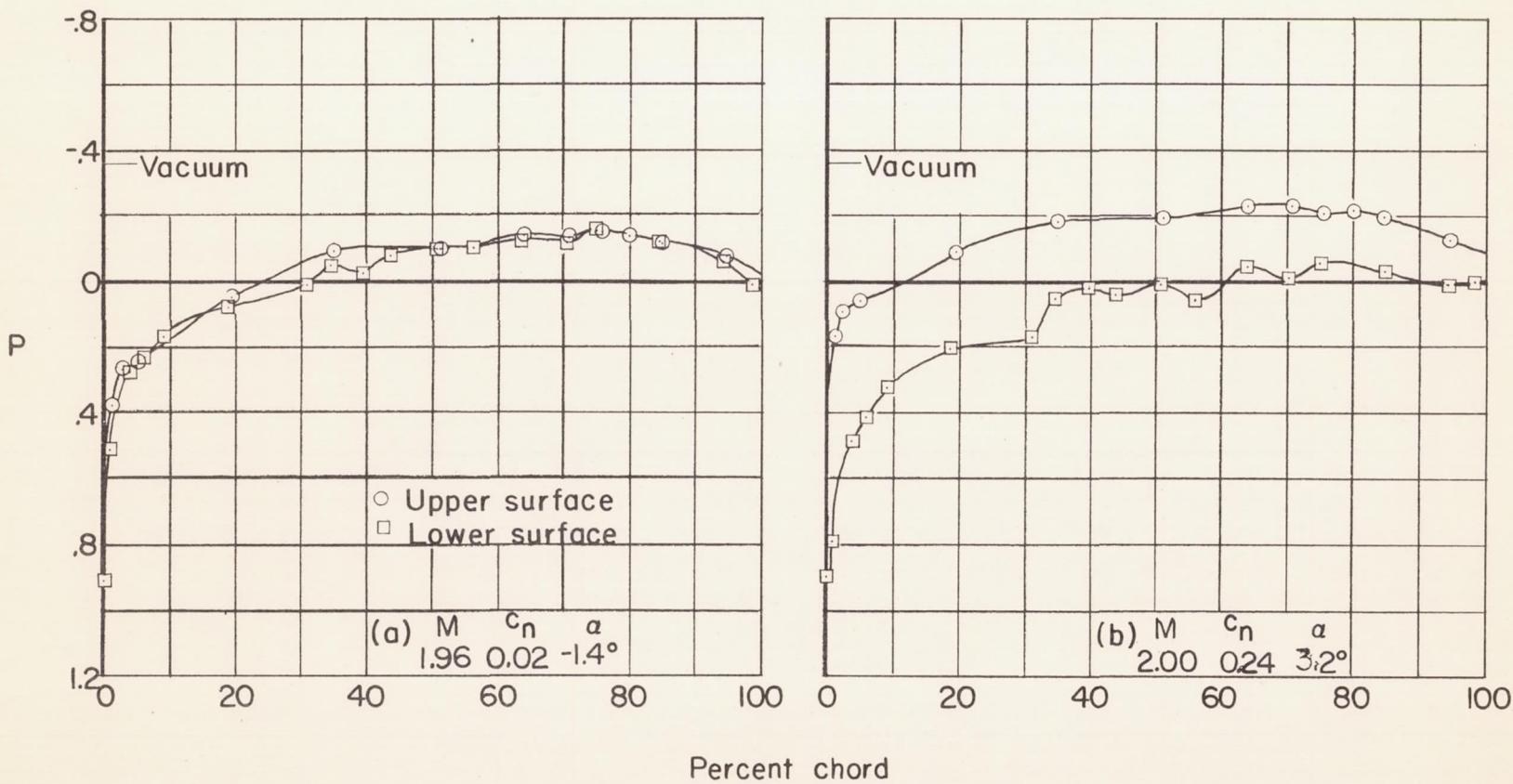


Figure 10.- Pressure distribution over a midsemispan wing station of the D-558-II research airplane. $M \approx 2.0$.

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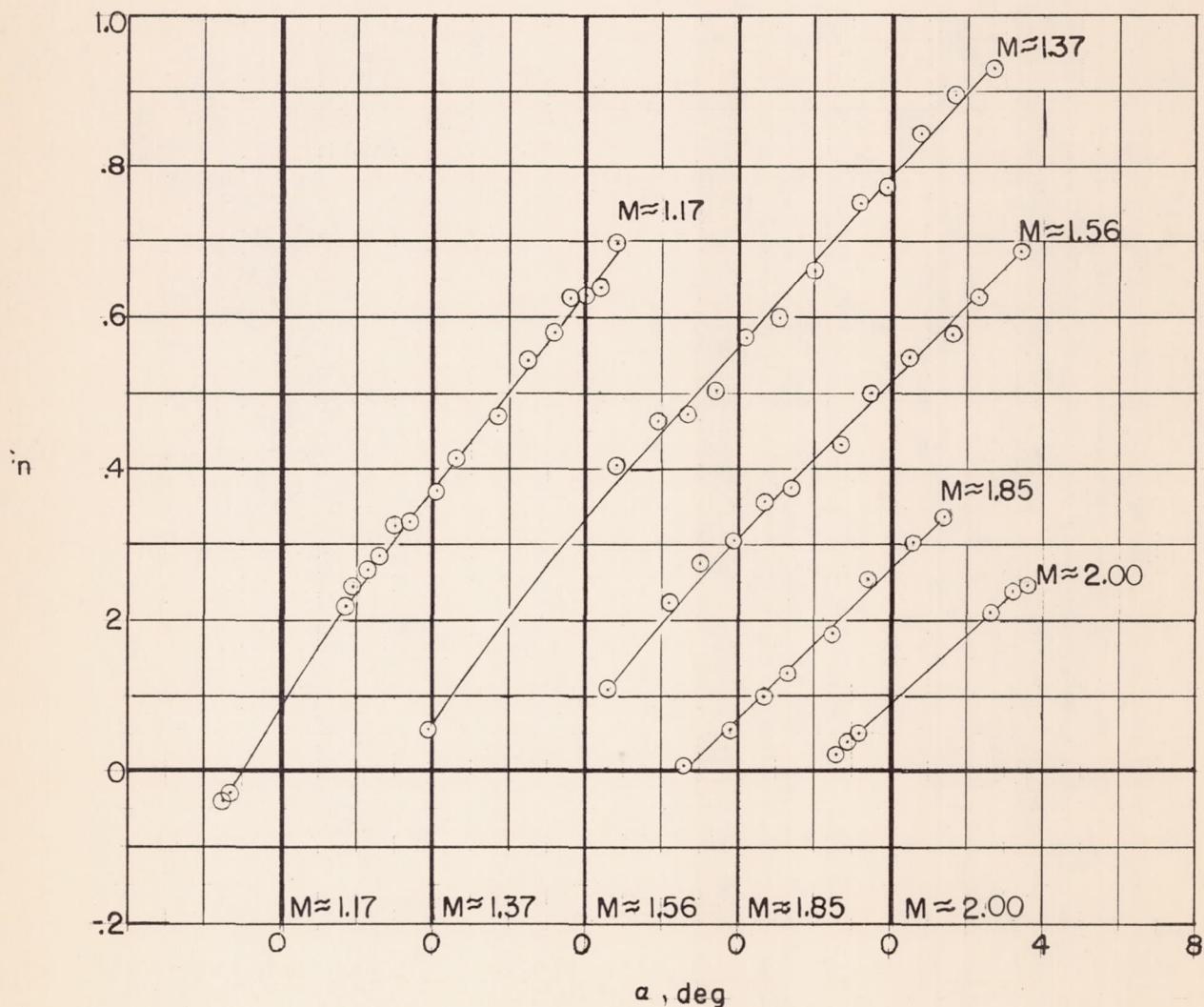


Figure 11.- Variation of wing section normal-force coefficient with air-plane angle of attack at several Mach numbers.

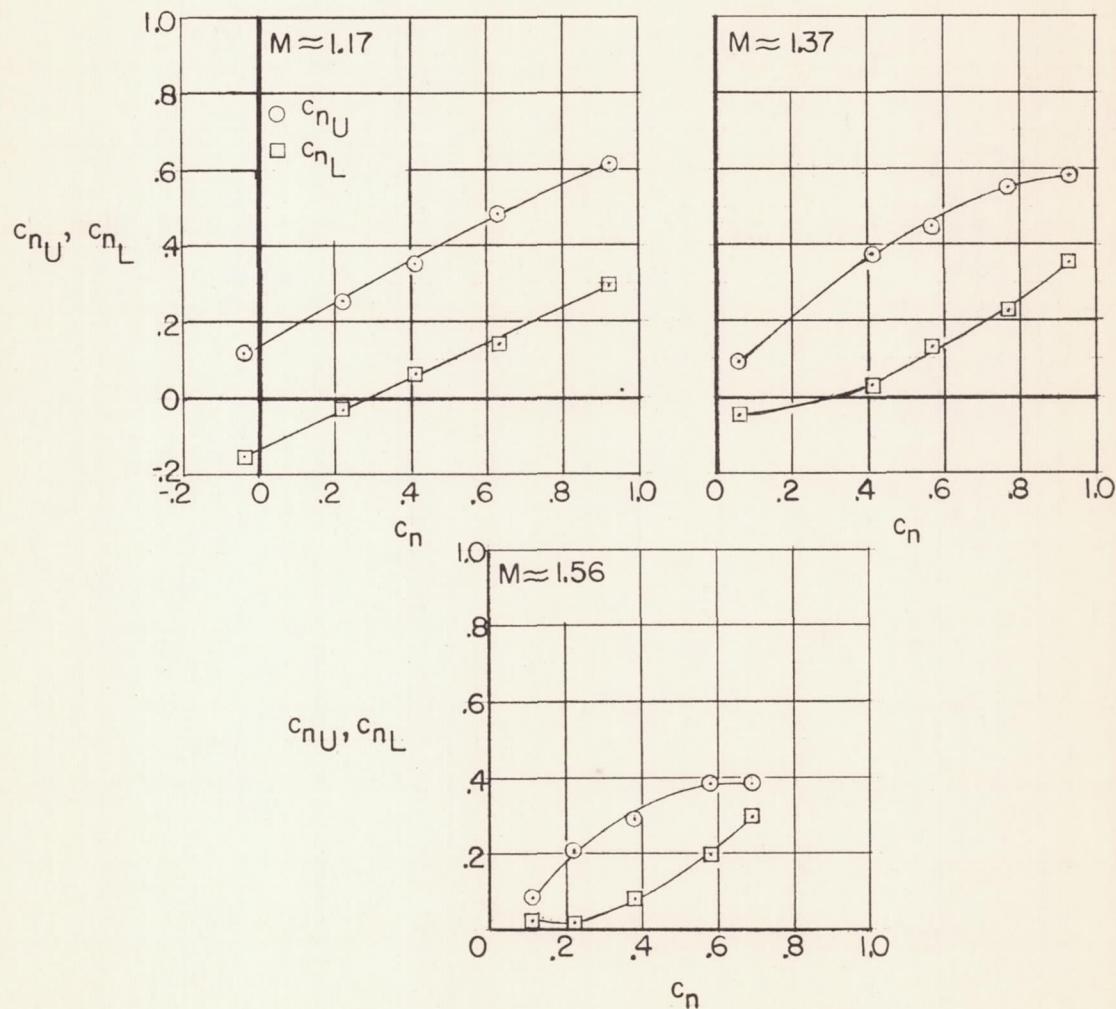


Figure 12.- Variation of upper- and lower-surface normal-force coefficients with total wing section normal-force coefficient at several Mach numbers.

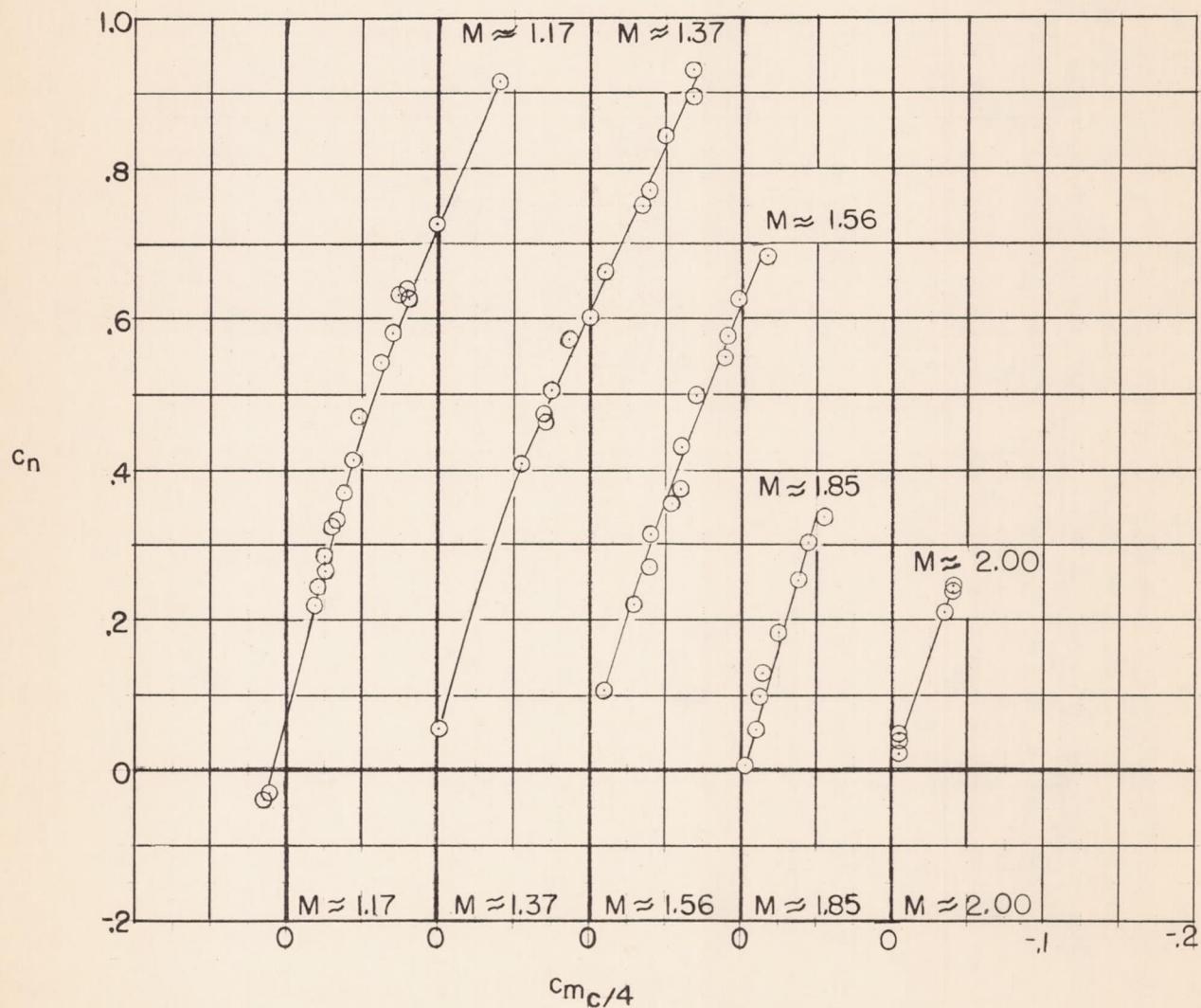


Figure 13.- Variation of wing section pitching-moment coefficient with wing section normal-force coefficient at several Mach numbers.

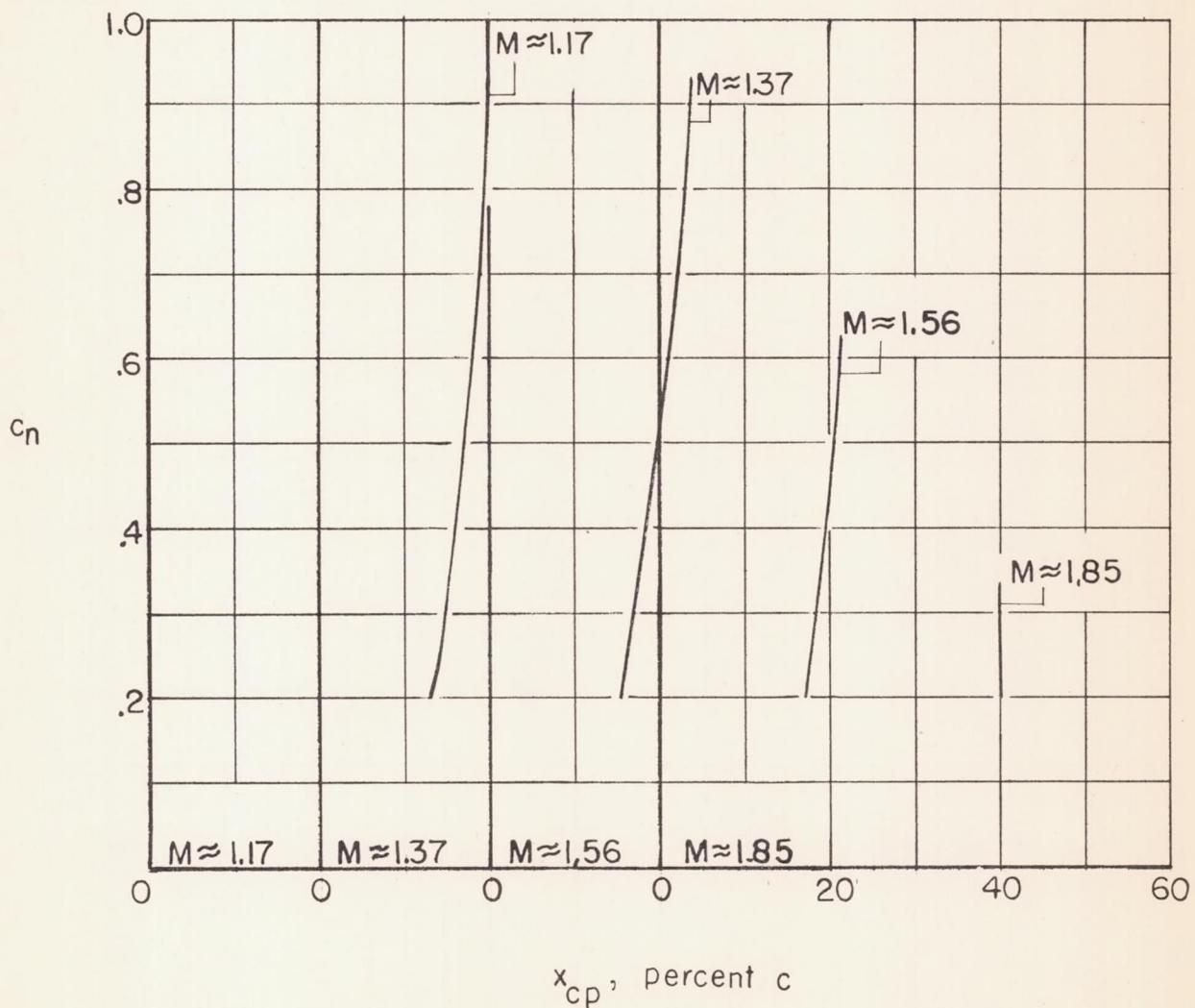


Figure 14.- Variation of wing section center of pressure with wing section normal-force coefficient at several Mach numbers.

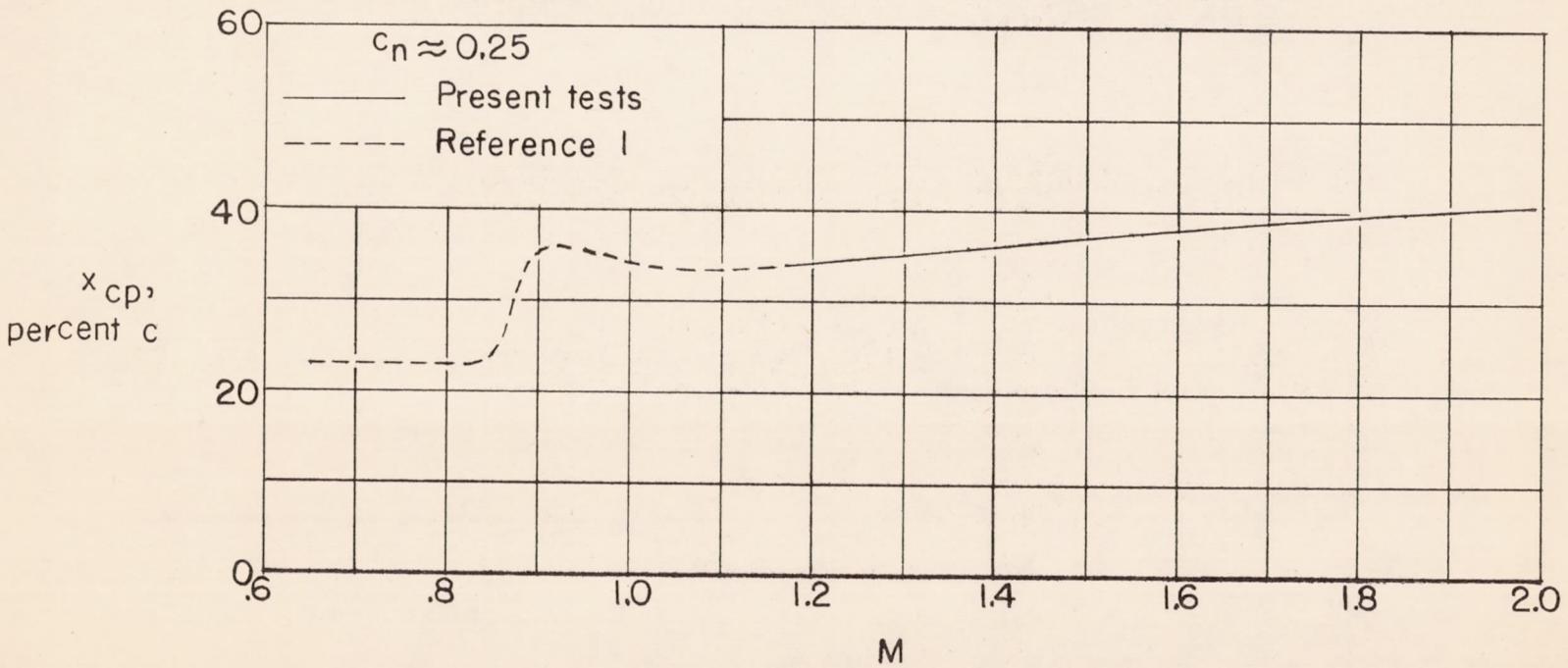


Figure 15.- Variation of center of pressure of the wing section with Mach number.